

Pubertal Development and Adolescent Sexual Behavior: Rethinking the Relevant Paths

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Abstract

Established theories and prior research suggest that the onset and type of an individual's sexual behaviors are rooted in timing of pubertal maturation, with girls who have an earlier timing of pubertal development more likely to exhibit early sexual onset and unstable sexual relationships. Utilizing a sample of female twin pairs (145 = MZ, 115 = DZ) from the National Longitudinal Study of Adolescent Health, the present study investigates associations between menarche and perceived pubertal development, age of first sexual intercourse, and adolescent dating and sexual behavior. Age at menarche predicted age of first sexual intercourse through a shared genetic pathway, but genes related to perceptions of physical development predicted engagement in different relationship contexts. These results confirm that menarcheal timing and developmental self-perceptions are etiologically distinct and may be differentially predictive of reproductive maturation, timing, and behaviors.

Biographical Sketch

Sarah Moore is a Ph.D. student in Human Development with a focus on adolescent development and the transition to social functioning in adulthood. Her work draws on methodology from both behavioral genetics and social neuroscience to answer questions regarding the interplay of genetic variation and adolescent social experience. Sarah received her B.S. in psychology at the University of Maryland in 2009, where she researched the role of maternal sensitivity on infant attachment, and the impact of client attachment on aspects of the client-therapist relationship. At Cornell, Sarah is investigating maturational pathways and personality factors contributing to adolescent sexual behavior, and how individual differences in phenotypic plasticity (or reactivity to the environment) manifest within different adolescent social contexts to shape adulthood outcomes.

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Introduction

The onset of romantic relationships and sexual behavior in adolescent girls occurs in the face of the drastic physical changes of pubertal maturation. The initiation of dating and sexual behavior is influenced not only by the biological changes of puberty, but also by individual-level interpretations of pubertal changes (Brooks-Gunn, 1984). The biological onset of puberty -- as well as psychological views of and reactions to maturation -- are moreover molded by distinct genetic and environmental pathways, which may carry over to influence subsequent sexual timing and behavior. Because reproductive timing holds considerable promise for understanding health and well-being at both an individual and societal level, the pubertal factors that influence adolescent transitions to romantic and sexual behavior are a source of longstanding research interest. The current paper assesses the associations between age at menarche, girls' perceived pubertal development, age at first sexual intercourse, and sexual activity inside and outside of romantic relationships utilizing a behavioral genetics approach. We address two topics: (1) the relations of both age at menarche and perceived pubertal development to timing and context of sexual behavior, and (2) the genetic and environmental pathways that contribute to these associations.

Puberty and Onset of Sexual Behavior

The first signals of reproductive maturation come at puberty with the development of secondary sex characteristics. In girls, these include general body growth and skeletal maturation, the growth of breasts, and onset of menarche (Goldstein, 1976). Consistently, a wide body of research links earlier timing of physical maturation relative to peers with an earlier age of first sexual intercourse, as well as with other outcomes correlated with earlier sexual onset, such as higher number of sexual partners, STIs, alcohol use, and age at first pregnancy (Dick,

Rose, Viken, & Kaprio, 2000; Stice, Presnell, & Bearman, 2001; Udry, 1979; Wichstrom, 2011). Explanations for the association between pubertal timing and age at first sex often implicate a biological mechanism, specifically the increase in hormonal androgens released during puberty. These hormones trigger feelings of sexual attraction and desire, which may manifest in sexual interest and activity. Indeed, compared to later developing peers, early maturers are more likely to initiate sexual behavior and have a greater interest in sex, which may be, at least in part, attributed to comparatively earlier surges of hormones (Diamond & Savin-Williams, 2009; Lam et al., 2002; B. Miller, Norton, Fan, & Christopherson, 1998). In support of this notion, early maturers demonstrate higher levels of testosterone than later maturers, one of the sex hormones involved in sexual desire (Udry et al., 1985, 1986).

In addition to the physiological correlates of early pubertal timing, certain socioenvironmental factors predict earlier development and may help explain the association of early pubertal timing with earlier sexual onset. These include reduced parental monitoring, living in a single-parent household, and tendency for early maturing girls to have older boyfriends and socialize with an older group of friends (Davis & Friel, 2001; Ge, Conger, & Elder, 1996; Vanoss Marin et al., 2000; Sieverding, Adler, Witt, & Ellen, 2005). These factors may moderate associations of pubertal timing with sexual onset; for example, adolescents experiencing conflict with a parent tend to have sex earlier, and this association is magnified among physically mature teens (McBride, Paikoff, & Holmbeck, 2003).

In addition to the question of *when* an individual becomes sexually active, another body of research articulates *the context* in which individuals engage in sexual behaviors. Sexual intercourse occurs most often in the context of a romantic dating relationship. Over 70% of adolescents have been involved in a romantic relationship by the end of high school (Carver,

Joyner, & Udry, 2003), and almost 65% of adolescents engage in sex over the course of a romantic relationship (Grello, Welsh, & Harper, 2006). However, adolescents also have sex with partners whom they are not dating; approximately one-third of sexually active adolescents engage in sexual intercourse both inside and outside of romantic relationships (Manning, Longmore, & Giordano, 2005). Colloquially, these non-romantic sexual experiences are often termed “hooking up” or “casual sex.”

Although often described as a modern adolescent phenomenon, “hooking up” has historically played a key role in evolutionary understanding of reproductive strategies. According to life history theorists (e.g., Belsky, Steinberg, & Draper, 1991), timing of puberty is a critical physiological link in determining both reproductive timing and behavior. According to this view, early puberty is triggered by recurrent, ongoing stressful early experiences, such as father absence, family conflict or low socioeconomic status. These environmental cues communicate the best time for the body to transfer energy from growth processes to reproductive processes, and determine the best reproductive strategy given environmental resources. An individual who develops in a stressful environment without the experience of safety, trusting caregivers, and abundant resources will have an earlier age of puberty, as well as earlier and unrestricted sexual behavior, including higher numbers of sexual partners and short-term, uncommitted sexual relations. This is because reproductive efforts are focused on quantity of offspring, rather than quality of parenting, a strategy which ensures higher chances for proliferation of one’s genes in a threatening and uncertain environment. On the other hand, when early environments are safe and abundant in resources, warmth, and social contact, early reproductive capacity is superfluous. Individuals raised in these environments will therefore have a later onset of puberty, and be motivated to delay initiation of sexual behavior, and skilled in developing and maintaining pair

bonds, as their strategy is to invest in lower number of offspring with higher quality rearing. Thus, later maturation and a focus on quality pair-bonds and parenting efforts can be seen as a logical and evolutionarily determined response to a safe environment abundant in resources; in contrast, earlier pubertal onset is a mechanism through which stressful early environments shape a reproductive strategy based on quantity of mates and offspring, rather than quality of pair bonds and child rearing.

Despite this theoretical prediction, no previous study has directly tested whether the timing of puberty is associated with sexual intercourse in a romantic versus a non-romantic relationship, and studies on the relation between pubertal timing and other outcomes associated with an “unrestricted” reproductive strategy have been mixed. Consistent with life history theory, earlier pubertal timing does predict earlier pregnancy and greater likelihood of single parenting (Dick et al., 2000; Stice et al., 2001; Udry, 1979; Wichstrom, 2011). Five studies, however, have investigated the effect of age at menarche on number of sexual partners and reported null results (Helm & Lidegaard, 1989; Hoier, 2003; Kim & Smith, 1998; Kim, Smith, & Palermi, 1997; Mikach & Bailey, 1999; see Ellis, 2004 for a complete review). Two additional studies (Hoier, 2003; Neberich, Penke, Lehnart, & Asendorpf, 2007) specifically targeted the effect of pubertal timing on sociosexual orientation, in which participants report their views and attitudes towards a sexual relationships, pairbonds and parental investment, and did not find significant associations. Given the paucity of previous research on this topic, it remains unclear whether early maturing girls are more likely to engage in sexual intercourse in a non-romantic relationship than later maturing girls.

The Role of Perceptions in Pubertal Timing

From a research standpoint, assessing and understanding the components of pubertal development is a surprisingly exigent task. This may be because puberty is a unique transition, spanning not just biological but social and emotional domains as well. It is perhaps the difficulty of capturing these multiple domains which has led to a considerable debate in the best methods for assessing physical development (Dorn & Biro, 2011; Dorn, Dahl, Woodward, & Biro, 2006). In general, measures which most accurately assess level of physical development relative to peers are preferred for research use (e.g., physical exam, menarche, hormonal assay) and self-assessments of maturational status are considered less valid indices. Such an approach is bolstered by the simple fact that children's self-perceptions of development tend to be only weakly related to more "objective" indicators of maturation (Brooks-Gunn, 1985). In fact, an adolescent's perception of whether she is an early or late maturer (relative to peers) relates more strongly to feelings about maturation than timing of maturation, assessed by age at peak height velocity (Dubas, Graber, & Peterson, 1991) or timing of menarche (Rierdan & Koff, 1985). Furthermore, individuals' perceptions of the timing of pubertal events may even encompass constructs other than puberty, such as body image (Boxer, Tobin-Richards, & Petersen, 1983).

Nevertheless, whether an adolescent perceives her pubertal maturation to be "early" versus "late" may be a salient determinant of behavior. Galambos, Kolaric, Sears, and Maggs (1999) reported that perceived maturity significantly predicted adolescent problem behavior, including relations with the opposite sex, delinquency, and drug use, after controlling for chronological age and pubertal status. This is particularly striking, given that these behaviors are often conceptualized as a desire to "seek maturity" and close the gap between biological and social maturity (e.g., Moffitt, 1993). In addition to associations with externalizing behavior, age at menarche and perceived development seem to influence dieting behavior (a marker of

internalizing) through separate pathways: although both are associated with engagement in dieting behaviors, this association is mediated by genetic differences in age at menarche versus environmental contributions to perceptions of maturation (Harden, Mendle, & Kretsch, 2012). Taken together, these findings suggest perceptions of development may influence the activities in which an adolescent engages, independent of level of objective physical development.

The Utility of a Behavior Genetics Approach

To the extent that pubertal timing is associated with the timing and context of sexual intercourse during adolescence, the mechanisms accounting for these associations are unclear. One field of research (see Rowe, 2002) suggests that the link between pubertal timing and the onset of reproductive behaviors may be attributed to heritable individual differences. Indeed, pubertal timing (Eaves, Silberg, Foley, Bulik, Maes, Erkanli, et al., 2004), and sexual behavior (Guo & Tong, 2006) are heritable. Using a sample of female twin pairs, Rowe (2002) reported that heritable genetic variation accounted for the connection between pubertal timing and the onset of sexual behavior, and suggested this connection could be explained by common genetically-determined physiological pathways (e.g. genes responsible for pubertal timing also initiate biological changes that yield increases in sexual desire).

Beyond a common genetic mechanism accounting for the link between pubertal timing and sexual behavior, there is also the possibility of *gene-environment correlation* or when genetically influenced traits can shape the likelihood of individuals encountering particular environments. Early developers who experience higher levels of hormonal androgens and thus physical changes at a younger age than peers may experience an environment with older-aged peers, higher levels of attention from boys, and more romantically charged interactions. Exposure to these environments may then lead to sexual behavior. Genes affecting how an

adolescent *experiences* her maturation, or her perceived pubertal development, may also influence her romantic and sexual environments. For example, a genetic predisposition for vigilance to environmental cues -- such as treatment from adults and peers -- may affect an adolescent's view of her level of development as well as her behavior in response to signals of attraction from potential partners.

Due to the genetic influence on pubertal timing, sexual behavior, and exposure to environments that affect the likelihood of sexual behavior, the pure impact of pubertal timing on the onset of sexual and romantic behaviors remains elusive. Indeed, in traditional epidemiological studies a clear inference for the impact of puberty on sexual behavior is difficult to achieve, despite the inclusion of multiple covariates to control for all of the possible influences of sexual behavior (SES, family structure, etc.). One critical problem is that it is simply not possible to control for all potential confounds, as it depends on the variables in the data set. Additionally, the inclusion of an exhaustive list of covariates introduces sources of measurement error; inevitably the constructs that are actually accounted for will vary considerably from one study to another. However, twin-comparison designs provides a means of naturally accounting for the impact of shared genetic effects, as well as any potential confounding environmental variables shared between twins reared in the same household. In this case, the impact of pubertal timing on sexual behavior can be delineated by comparing girls who differ in the timing of menarche and perceived pubertal timing, but who also possess common genes and family environments.

In the present research, we employ a behavioral genetics design to investigate age at menarche and perceived pubertal timing as predictors of the timing and context of adolescent sexual activity. This design allows us to determine the extent that the associations between

puberty and sex are due to selection factors that vary between families, as well as the nature of the pubertal predictors; do genes or environmental experiences (or both) which underlie pubertal timing predict the likelihood of earlier sex as well as likelihood of sex in different relationship contexts?

Goals of the Current Study

In the present study, we employ twin comparisons to investigate the environmental and genetic pathways between both age at menarche and perceived pubertal development with 1) age at first sexual intercourse, and 2) engagement in dating, sexual activity inside a romantic partnership, and sexual activity outside of a relationship (collectively referred to as “relationship context.”) Our analyses consider two research questions. First, to what extent do age at menarche and perceived pubertal development predict the timing and context of adolescent sexual intercourse? Are these associations attributable to common genetic influences?

Evolutionary theorists predict that both timing and types of sexual behavior are related to timing of menarche, all of which reflect conditional adaptations to early environments. If timing of menarche predicts both the age at first intercourse and the contexts of sexual behavior, this would be in support of evolutionary theories of reproductive strategies, particularly if those associations were mediated along environmental mechanisms. On the other hand, other theorists (see Rowe, 2002) argue that heritable variation accounts for the association between pubertal timing and onset of sexual behavior: genes influencing the timing of development are also influencing biological changes yielding sexual desire and the onset of sexual intercourse. This idea would be supported if timing of menarche predicts age at first intercourse through a genetic path. Furthermore, if genes influencing an individual’s *experience* of maturation affect either timing of first sex or the contexts of sexual behavior (e.g. dating, romantic and non-romantic

sex), the view that heritable variation accounts for traits and behavior across development would be supported.

Method

Participants

Data were drawn from the National Longitudinal Study of Adolescent Health (Add Health; Udry, 2003), a nationally representative study assessing adolescent health and risk behavior collected in four waves between 1994 and 2008. A stratified random sample of US high schools was targeted by the study, and 79% of schools selected agreed to participate (N = 134 schools). Of these participating schools, 96% administered a confidential in-school interview during the 1994-1995 academic year (N = 90,118). From this in-school sample, a total of 20,745 participants (10,480 females) were randomly selected from rosters of the participating schools to complete a 90-minute in-home interview between April and December of 1995 (Wave I interview, mean age = 16.12 years, S.D. = 1.67). Three follow up interviews were completed in 1995-1996 (Wave II interview), 2001-2002 (Wave III) and in 2007-2009 (Wave IV). For sensitive topics, participants listened through earphones to audio-recorded questions and entered answers into a laptop.

During the in-school interview, adolescents were asked whether they currently lived with another adolescent, which was used to oversample adolescent sibling pairs residing in the same home even if one member did not attend a high school in the original probability sample. The present study utilizes a subsample of female-female twin pairs (145 monozygotic and 114 dizygotic pairs). Twin pair zygosity was determined through 11 molecular genetic markers as well as responses to four questionnaire items addressing physical appearance and how often the respondent was mistaken for her twin (Harris, Halpern, Smolen, & Haberstick, 2006). The

sociodemographic composition of the pairs subsample is comparable to that of the full Addhealth sample (Rowe & Jacobson, 1999).

Measures

Age at menarche. Participants were asked at Waves I and II if they had ‘ever had a menstrual period?’ and, if so, during which month and year they had experienced their first menstrual cycle. At Wave III, participants responded to the item, “how old were you when you got your period for the first time?” To reduce telescoping bias (Pickles, Pickering, Simonoff, Silberg, Meyer, & Maes, 1998), we used the first reported age at menarche, which was most often Wave 1 (87 % of the sample). The mean age at menarche was 12.31 years ($SD = 1.46$; Range – 8 – 18 years).

Perceived Pubertal Development. Perceptions of maturation were assessed using three items from Wave 1 on self-ratings of physical development. The first item assessed general level of development relative to peers (“*How advanced is your physical development compared to other girls your age?*” where 1 = *I look younger than most* and 5 = *I look older than most*). The next two items asked participants to assess changes in body shape. Changes in breast development were rated on a scale where 1 = “*my breasts are about the same size as when I was in grade school*” and 5 = “*my breasts are a whole lot bigger than when I was in grade school; they are as developed as a grown woman’s breasts.*” Likewise, curviness was rated from 1= “*my body is about as curvy as when I was in grade school*” to 5= “*my body is a whole lot more curvy than when I was in grade school.*” We standardized the mean score by age in years for each item, and then averaged the three items such that higher scores represent perception of greater physical changes compared to individuals of the same age and lower scores represent perception of fewer

changes compared to same-age individuals. Scores on this scale could range between -6.82 and 5.01. The mean perceived pubertal development was -0.39 ($SD = 2.46$).

Age at first intercourse. At each wave participants were asked whether they had ever had vaginal intercourse and, if so, their age at first sexual intercourse. To minimize reporting bias, we used the age reported in the earliest wave that the participant endorsed having sex (Upchurch, Lillard, Aneshensel, & Li, 2002) except in cases where an age of first sex preceded eleven years of age (which seemed potentially nonconsensual). The mean age at first intercourse for the sample was 16.84 years ($SD = \text{standard deviation}$)

Dating and sexual activity. Participants were asked during the Wave 1 interview whether they had a ‘special romantic relationship’ within the past 18 months; if the participant answered “yes” they were classified as dating (Dating = 1). If the adolescent denied having a special romantic relationship, but had told another non-related person that she “liked or loved them”, and had held hands and kissed the person, the participant was also classified as being in a dating relationship. For each dating relationship (up to 3), adolescents reported whether they had sexual intercourse in that relationship. If the adolescent answered yes to sexual intercourse in any of the dating relationships, they were classified as having romantic sex (Romantic Sex = 1). Adolescents also reported whether they had ever had a sexual relationship with anyone, “not counting the people you described as romantic relationships.” If adolescents answered “yes” to this question, they were classified as having non-romantic sex (Non-romantic Sex = 1). This coding scheme had the advantage of creating relationship contexts that were not mutually exclusive categories: for example, adolescents who reported sexual activity both in and out of romantic relationship were scored as Dating = 1, Romantic Sex = 1, Non-Romantic Sex = 1. Adolescents who reported that they were virgins were classified as not having romantic or non-

romantic sex (Dating = 1 or 0, depending on report; Romantic Sex = 0 and Non-Romantic Sex = 0).

Data Analyses

As a preliminary step, we utilized means comparisons to investigate genetic and shared environmental effects that may confound the associations between physical maturation and dating, sexual activity in a romantic relationship and non-relationship sexual activity. For this analysis, we investigated the difference between the *phenotypic* effect of puberty on relationship contexts (not controlling for genetic and shared-environmental confounds) and the *within-family* effect (taking into account differences in environmental and genetic third variables which vary among participants reared in different families).

In line with traditional correlational designs, the phenotypic effect demonstrates the basic association between age at menarche and perceived maturation to relationship contexts, not accounting for genetic and major environmental differences which may exist among participants raised in different families. Participants were divided into groups based on dating relationships and sexual activity, and the mean score of age at menarche for participants that engaged in the behavior (i.e. relationship sex = 1) was subtracted from the mean for participants that did not engage in the behavior (relationship sex = 0). These differences were divided by the pooled standard deviation to yield the effect size (Cohen's *d*). The same effect was computed for mean perceived development.

For the within-family effect, pair-level averages were computed for each of the three relationship contexts (dating, sexual activity with a romantic partner, sexual activity with a non-romantic partner) by averaging siblings' scores in each pair. Pair-wise variables hold values of 0 (neither sibling was involved in that behavior), 0.5 (one sibling was involved and the other was

not) or 1 (both siblings engaged in the behavior). Individual-level deviation scores were then computed by subtracting the pair-wise averages from each individual's score, yielding scores of -0.5 (one sibling did not date, engage in relationship sex, etc. but her sister did), 0 (the siblings were concordant for the behavior, in that both engaged or did not engage), or 0.5 (one sibling engaged in the behavior and the other did not). To determine the effect size, the means of age at menarche or perceived development were averaged for the two discordant groups (deviation scores = -0.5 or 0.5) and subtracted from the mean for the concordant group, and then divided by the pooled standard deviation. This within-family effect inherently controls for genetic similarity and environmental factors shared by siblings, such as socio-economic status and parenting. If the magnitude of the within-family effect is attenuated compared to the phenotypic effect, then genetic and/or shared environmental factors in the same family may account for differences in dating and sexual behavior.

Behavioral genetic models. The software program Mplus (Muthen & Muthen, 1998-2010) was used to estimate a series of behavioral genetic models decomposing the variance of the measured phenotypes into three latent factors: additive genetic (A); shared environmental (C); and non-shared environmental (E) (e.g., Neale & Cardon, 1992). Additive genetic influences refer to quantitative genetic inheritance, such that the combined effects of genetic alleles are equal to the sum of their individual effects. The shared environmental factor represents all environmental experiences that are shared between twins (e.g. socioeconomic status, family structure, school district) and the non-shared environmental factor accounts for experienced influencing the phenotype that are unique to each twin (e.g. differential treatment from parents or different peer groups) as well as the error term. In line with previous analyses (Ge, Natsuaki, Neiderhiser, & Reiss, 2007; Harden, Mendle, & Kretsch, 2012), preliminary models indicated

that shared environmental contributions to both puberty measures were negligible and could be dropped from the full model without decreasing model fit (full results available from first author on request). Thus, for all models, only additive genetic and non-shared environmental influences on timing of menarche and perceived development were estimated. Model 1 assesses the genetic and environmental influences of both age at menarche and perceived maturation on age at first intercourse (AFI; Figure 1). The parameters of interest in Model 1 are the regressions of age at first intercourse on the additive genetic (A; see paths bA1 and bA2) and non-shared environmental (E; paths bE1 and bE2) variance components of both measures of pubertal timing. These regressions assess (1) do the genes and nonshared environmental factors that influence timing of menarche also predict timing of first sex (bA1 and bE1), and (2) after accounting for the genetic and environmental determinants of age at menarche, do genetic and nonshared environmental influences on perceived development account for additional variance in age of first intercourse (bA2 and bE2)? Model 1 therefore addresses the pubertal factors contributing to when people become reproductively mature.

Three additional models (Figure 2) target *in what ways* people transition to reproductive activity by assessing the genetic and environmental influences of both age at menarche and perceived maturation on dating (Model 2), relationship sex (Model 3), and non-relationship sex (Model 4). Because preliminary models of the three relationship context measures indicated that shared environmental influence on dating, relationship sex, and non-relationship sex were negligible, only A and E were estimated (full results available upon request). Again, the parameters of interest are the regressions from genetic and environmental factors accounting for pubertal maturation on the three relationship contexts. Thus, do genes and unique environmental experiences accounting for timing of menarche predict (1) whether an adolescent dates, engages

in relationship sex, or engages in non-relationship sex (bA1 and bE1), and (2) to what extent do genes and unique environmental experiences accounting for perceived development predict these behaviors (bA2 and bE2) after taking age at menarche into account?

Results

Means Comparisons: Level of Pubertal Timing According to Relationship Context

As a preliminary step, we conducted a series of means comparisons for both age at menarche and perceived pubertal timing according to relationship context (Dating, Romantic Sex, Non-Romantic Sex). As shown in Figure 3, the mean age at menarche is significantly lower for adolescents who date (dating = 12.08; no dating = 12.53; $t = 2.11$, $p < 0.05$), with nonsignificant differences for engaging in romantic sex (relationship sex = 12.11; no relationship sex = 12.30; $t = 0.41$, $p > 0.05$) and non-romantic sex (non-relationship sex = 12; no non-relationship sex = 12.32; $t = 1.13$, $p > 0.05$). With regard to perceived development (Figure 4), adolescents who engage in all three contexts report perceiving themselves as significantly more developed than adolescents that do not date (dating = 9.76; no dating = 8.9; $t = -3.59$, $p < 0.01$), do not have romantic (relationship sex = 10.27; no relationship sex = 9.16; $t = -3.96$, $p < 0.01$), and do not have non-romantic sex (non-relationship sex = 9.99; no non-relationship sex = 9.29; $t = -2.05$, $p < 0.05$). Figure 5 displays the effect size (Cohen's d) calculations for phenotypic and within-family effects. The black bars represent the phenotypic effect, and suggest small effects for age at menarche on dating and non-relationship sex, and moderate effects of perceived development on all three behaviors. As displayed by the gray bars, the effect of menarche on all three relationship contexts is greatly attenuated compared to the within-pair effect. Likewise, the within-family effect of perceptions on relationship contexts is attenuated, but the effects are small, rather than absent, for relationship sex and non-relationship sex. The attenuation of

within-family effects relative to phenotypic effects indicate that the association of age at menarche and perceived development on the involvement in dating, relationship sex, and non-relationship sex may be due in part to between-family differences in environmental experiences and/or genes.

Behavioral Genetic Models

What are the associations between age at first intercourse, perceived development, and menarche? As a preliminary step, we estimated the correlations among age at menarche, perceived development, and age at first intercourse. Age at menarche was significantly correlated with perceived development ($r = -0.28, p < 0.01$) and age at first intercourse ($r = 0.14, p < 0.01$). The relation between perceived development and age at first intercourse did not reach statistical significance ($r = -0.07, p > 0.05$). Additionally, we compared the correlations between MZ twins to those between DZ twins for each variable. As shown in Table 1, both MZ and DZ twins' scores on age at first intercourse, age at menarche, and perceived pubertal development were significantly related, and these correlations, as expected, were higher between MZ twins. A higher relation between MZ twins than DZ twins suggest that genes play a part in the similarity of these traits between twins. Finally, before conducting phenotypic versus within-twin means comparisons for the puberty variables and age at first intercourse, we tested for statistical differences between early versus late age at menarche on age at first sex, and lower versus higher perceive pubertal change. Adolescents with earlier versus later age at menarche significantly differed in their age at first sex (for menarche = 0, mean = 16.43; menarche = 1, mean = 17.03; $t = -2.55, p < 0.05$), and adolescents with higher perceived physical changes differed in their mean age at first intercourse than those perceiving lower physical changes (perceptions = 0, mean =

16.81; perceptions = 1, mean = 16.46; $t = 1.93$, $p = 0.05$), but with borderline statistical significance.

In Model 1, we fit a behavioral genetic model of age at menarche, perceived development, and age at first intercourse ($\chi^2 = 41.94$, $df=35$, $p = 0.20$, RMSEA = 0.04). For age at menarche, 61.4 % of the variance in the trait can be attributed to genes, and 38.6 % to unique environment, and these components significantly predicted the respective trait. After accounting for timing of menarche, 45 % of the variance of perceived development is due to genes and 55 % to unique environmental factors, and these variance components significantly predicted perceived pubertal development. Finally, after accounting for both pubertal variables, 28.7 % of the variance in age at first intercourse is due to genes, 29.8 % to shared environmental factors, and 41.5 % to non-shared environmental factors (all predict age at first intercourse significantly; see *Variance Components* section of Table 2).

There are several notable results from the analyses assessing how the genetic and unique environmental factors for one phenotype predict phenotypes entered subsequently in the model (displayed in *Regression Coefficients* section of Table 2). These analyses test the extent that genes and unique environmental factors influencing age at menarche and perceived development predict age at first intercourse. First, as we previously reported in analyses of this data set (Harden, Mendle, & Kretsch, 2012), a genetic path accounts for the variance shared between age at menarche and perceived pubertal development ($b = 0.88$, $p < 0.01$, see bA1 in Figure 1), indicating that common genes influence both timing of puberty and how developed an adolescent perceives herself. Additionally a significant genetic path accounts for shared variance between menarche and age at first intercourse ($b = 0.34$, $p < 0.05$, see bA2 in Figure 1), indicating that genes accounting for when an adolescent experiences menarche also affect when she engages in

sex. Unique environmental influences on age at menarche and perceived development did not significantly predict age at first intercourse, suggesting that the environmental experiences that affect pubertal timing and perceived pubertal timing are independent of the environmental experiences which predict timing of first sex. Follow-up calculations indicated that the latent genetic factors underlying age at menarche and those underlying perceived development were significantly correlated with each other ($r = -0.49$, $p < 0.01$). This relationship reflects the significance of genes accounting for perceived development regressing on age at menarche, and merely adds to the results that genes common to both age at menarche and perceived development are significantly related. The variance components, parameter estimates, correlated factors and indices of fit for Model 1 are displayed in Table 2.

How does pubertal timing predict the relationship contexts of reproductive behaviors? Models 2-4, investigated the influence of age at menarche and perceived development on likelihood of dating (Model 2), relationship sex (Model 3) and non-relationship sex (Model 4) are summarized in Table 3. All models had good model fit, and all variance components (see *Variance Components* section of Table 3) significantly predicted their respective measure after accounting for the construct(s) entered prior. As was the case for Model 1, genes accounting for menarche predicted perceived development (bA1 in Figure 2) and these genetic factors were significantly correlated in all three context models. The result that the genetic factor accounting for age at menarche associates with the genetic factor partially composing perceived development, suggests that genes common to both age at menarche and perceived development are significantly related.

In all three models, neither genetic nor environmental factors underlying age at menarche significantly predicted dating, relationship sex, or non-relationship sex (see bA1 and

bE1 in Figure 2). In contrast, perceived pubertal development significantly predicted contexts of sexual behavior through genetic pathways (portrayed as bA2 in Figure 2). Genes influencing perceived pubertal development predicted the likelihood an adolescent engaged in dating relationships ($b = 0.29, p < 0.05$), sex in romantic relationships ($b = 0.48, p < 0.01$) and non-romantic sex ($b = 0.30, p < 0.05$). This suggests that genes accounting for how developed a girl perceives herself to be influence her likelihood of dating, engaging in relationship sex, and engaging in non-relationship sex.

Discussion

Genetic and environmental predispositions mold developmental trajectories, affecting when a girl matures, how she may interpret her biological changes, and her sexual and romantic behaviors. The current study suggests that pubertal timing, as measured by age at menarche, predicts *when* individuals first engage in sexual intercourse. After controlling for age at menarche, perceived pubertal development predicts *the contexts in which sexual behavior occurs*, with girls who perceive themselves to be earlier maturing more likely to date, have sex in romantic relationships, and have sex in non-romantic relationships. These findings echo two themes in the empirical puberty literature. First, the onset of sexual behavior is connected to the timing of pubertal development, suggesting that timing of reproductive behavior reflects biological capacity. Second, the social contexts of the relationships in which sexual behavior is initiated are influenced by how reproductively mature an adolescent believes herself to be.

These results highlight several points regarding the transition to reproductive maturity and sexual behavior. Our findings are consistent with previous research implicating a shared genetic path between timing of menarche and age at first intercourse (Rowe, 2002). This seems most likely attributable to genes influencing the timing of the secretion of reproductive

hormones that increase feelings of sexual desire as well as levels of sexual attractiveness to others (Diamond & Savin-Williams, 2009; Halpern, 2003). Second, we found no associations between timing of menarche and adolescents' involvement in dating, romantic sex, or non-romantic sex. This is incongruent with elements of life history theory, which consider earlier menarche to be the initial step in a trajectory of accelerated reproductive development, sporadic relationships, and high numbers of uncommitted sexual partners. Rather, engagement in non-romantic sexual activity was predicted by perceived pubertal development. The idea that psychological perceptions can have differential impacts than objective realities is not new to psychology; for example, research suggests that perceived measures of social support, socioeconomic status and racism can be more strongly associated with physical and psychological outcomes than objective measures of these phenomena (Adler, Epel, Castellazzo, & Ickovics, 2000; Schaefer, Coyne, & Lazarus, 1981; Williams, Neighbors, & Jackson, 2003). We consider the present findings therefore congruent with a larger body of work implicating the salience of perceptions in behavior and well-being.

Which genes might underlie associations of perceived development with engagement in particular relationship contexts? One possibility is that genes influencing personality traits may concomitantly affect perceptions of one's development as well as sexual behavior in romantic and non-romantic engagements. How an adolescent idiosyncratically responds to her social world affects how she perceives herself within various contexts, and likely drives her social behavior as well. For example, high levels of neuroticism might predispose an individual to be highly vigilant to the physical changes of puberty, and prone to ruminate about these changes as well as to how others respond to them. In this case, dating and/or sexual behavior may help resolve feelings and perceptions of maturation. Conversely, an adolescent with low levels of

neuroticism may feel comfortable and confident in response to her physical changes, and perceive the self as both physically and emotionally prepared for the experience of pleasure and social connection in a dating and/or sexual relationship. A second interpretation is that a common set of genes affect perceived maturation, dating and sexual behavior, and the psychological disturbance associated with these behaviors. An adolescent suffering from depressive symptoms could be predisposed to perceive her transition to reproductive maturation negatively. Dating and sexual activity may arise as a means of self-validation for young girls with low self-esteem and distress over becoming ‘overweight’ and unattractive when their bodies no longer reflect the slender ideal portrayed by the media.

Limitations

Although the present study interprets findings under the assumption that dating and sexual outcomes are preceded by subjective views of puberty, it is important to note that the cross-sectional analyses do not allow us to determine the temporal sequencing of these associations. In particular, it is possible that engaging in dating or sexual relationships, either concurrently or previously, helps shape how developed an adolescent feels. In addition, our sample did not include adolescent males. This is partly a byproduct of the nature of puberty, which lacks a sufficient male counterpart to age of menarche, making it difficult to differentiate typical physiological processes from perceptions. We suspect; however, that for males the effects of perceptions would trump those of the timing of maturation in predicting dating and sexual behavior as was demonstrated with females. The impact of psychological perceptions on behavior and psychological outcomes is well-supported by research, and how developed a young man perceives himself to be likely affects his interest and pursuit of sexual and romantic engagements, beyond physiological developmental status. This finding would further support

that dating and sexual behavior is a product of a complex web of genetically-influenced individual psychological differences and social experiences.

In addition, it is worth noting that the present study – along with the majority of research on pubertal development --focuses on adolescent girls and does not consider comparable associations in boys. We suspect that this bias within the literature occurs for two reasons. First, although the evolutionary theory (e.g. Belsky et al., 1991, from which much of the research on puberty and sociosexual orientation is drawn), predicts precocious puberty, earlier sex, and unstable pair bonds for both males and females, there is a more detailed theoretical explanation on how the onset of menarche in girls through the metabolic effects of “internalizing” problems initiates earlier sexual activity. Adolescent boys, in contrast, are theorized to go through puberty earlier through “some unspecified biological mechanism” (p. 653). The second reason for an emphasis on female maturation may be less theoretical and more methodological: self-reported menarche is a convenient and reliable measure of how early or late an adolescent girl matures. Despite efforts to identify alternatives, a comparably efficient self-reported physiological measure for males is not currently available and this constrains the number of comparisons which can be made across genders.

Finally, although twin comparisons are powerful quasi-experimental designs (e.g., Johnson, Turkheimer, Gottesman, & Bouchard, 2009), the present study did not explicitly test for gene x environment interaction. Thus, we cannot rule out the possibility that environmental factors not considered in this study may moderate genetic influences on maturation and sexual behavior. For example, previous behavioral genetic studies support that the extent a trait is heritable may depend on levels of environmental stressors, such that ‘genetic potential’ is often reached in less stressful environments, and the impact of environment is greater on traits when

levels of stress are high. In the case of our present findings, this would mean that the sexual behavior of participants in minimally stressful environments may be influenced by genes to a greater degree than participants in a strongly adverse environment.

Conclusions

The current research addresses the complexities of the transition into reproductive maturity and subsequent romantic and sexual behavior. Our findings suggest that how adolescents perceive their development is a potent predictor of the likelihood of engaging in three distinct relationship contexts. There are two important implications of this result. First, given the adverse psychological sequelae of adolescent dating and sex, the acknowledgement of perceived development as an accurate precursor of these types of behavior could greatly improve the conceptualization of ‘risk factors’ for adolescent problematic behavior and psychopathology. Previous research has demonstrated that perceived development additionally predicts likelihood of eating disorders above and beyond objective timing of puberty. Adding the context of sexual behavior to this picture -- and thus the differential psychological consequences of these contexts (i.e. dating versus casual sex) -- highlights the importance of perceived development to the psychological sequelae of early pubertal timing.

Second, the present research suggests perceived development may be a more important antecedent to dating and sexual behavior than age at menarche. This finding has clear potential for prevention and intervention efforts. Federal education policies aim to promote abstinence from sex, due to its “harmful psychological and physical effects” (Title V, Section 510(b)(2)(A-H) of the Social Security Act, P.L., 104-193), yet such programs have not been fully successful in changing adolescents’ sexual behavior or in reducing rates of pregnancies and STIs (Kirby, 2007; Kohler, Manhart, & Lafferty, 2008). Directing attention and interventions to adolescents’

perceived maturation may provide a novel adjunctive to sex-education programs, by pinpointing a malleable mechanism of risk.

Certainly, for some adolescents, the transition to reproductive maturity is tumultuous and difficult, and can be exacerbated by the intensity of novel romantic and sexual relationships; indeed, engagement in dating and sexual intercourse as an adolescent is often accompanied by high levels of depression and self-esteem difficulties (Connolly, & McIsaac, 2009; Hallfors, Waller, Bauer, Ford, & Halpern, 2005; Meier, 2007; Spriggs & Halpern, 2008). The results of the present study suggest that the timing of reproductive behavior reflects genetically mediated biological process but the manner in which adolescent sexuality occurs is related to how mature an adolescent believes herself to be. Biology may determine the timing of puberty and the timing of sexual onset through common genetic effects, yet a psychological circumstance plays a role in how this transition manifests behaviorally.

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Table 1

Within-Pair Twin Correlations for Age at first Intercourse, Menarche, and Perceived Development

| | MZ Twins | DZ Twins |
|-----------------------|-------------|-------------|
| AFI | 0.57 | 0.45 |
| Menarche | 0.61 | 0.31 |
| Perceived Development | 0.45 | 0.37 |

*Significantly different than zero at $p < 0.05$.

AFI = age at first intercourse.

Table 2

Model 1: Trivariate Model of Menarche, Perceived Development, and AFI

| | |
|--------------------------------|--------------------|
| <i>Variance components</i> | |
| Menarche A | 1.14 (0.07) |
| Menarche E | 0.91 (0.05) |
| Perceptions A | 1.44 (0.14) |
| Perceptions E | 1.60 (0.13) |
| AFI A | 1.11 (0.40) |
| AFI C | 1.13 (0.34) |
| AFI E | 1.33 (0.09) |
| <i>Model fit</i> | |
| RMSEA | 0.04 |
| CFI | 0.97 |
| TLI | 0.97 |
| χ^2 , df (p) | 41.94, 35, 0.20 |
| <i>Regression Coefficients</i> | |
| bA_Menarche_Perceptions | 0.88 (0.17) |
| bE_Menarche_Perceptions | 0.02 (0.14) |
| bA_Menarche_AFI | 0.34 (0.16) |
| bE_Menarche_AFI | 0.06 (0.13) |
| bA_Perceptions_AFI | 0.13 (0.20) |
| bE_Perceptions_AFI | 0.14 (0.12) |

*Significantly different than zero at $P < 0.05$. AFI = age at first intercourse.

Table 3

Models 2-4: Trivariate Models of Menarche, Perceived Development, and Three Relationship Contexts

| | Model 2 | Model 3 | Model 4 |
|--------------------------------|---------------------|---------------------|----------------------|
| | Dating | Relationship Sex | Non-Relationship Sex |
| <i>Variance components</i> | | | |
| Menarche A | 1.14 (0.07) | 1.14 (0.07) | 1.14 (0.07) |
| Menarche E | 0.89 (0.05) | 0.89 (0.05) | 0.89 (0.05) |
| Perceptions A | 1.48 (0.15) | 1.48 (0.15) | 1.48 (0.15) |
| Perceptions E | 58.6 (0.06) | 58.6 (0.06) | 58.6 (0.06) |
| Context A | 0.81 (0.19) | 0.84 (0.11) | 0.77 (0.11) |
| Context E | 0.51 (0.13) | 0.25 (0.07) | 0.53 (0.10) |
| <i>Model fit</i> | | | |
| RMSEA | 0.06 | 0.03 | 0.01 |
| CFI | 0.96 | 1 | 1 |
| TLI | 0.96 | 1 | 1 |
| χ^2 , df (p) | 47.52, 34, 0.06 | 37.52, 34, 0.31 | 35.55, 34, 0.44 |
| <i>Regression Coefficients</i> | | | |
| bA_Menarche_Perceptions | -0.77 (0.16) | -0.77 (0.16) | -0.77 (0.16) |
| bE_Menarche_Perceptions | -0.03 (0.12) | -0.03 (0.12) | -0.03 (0.12) |
| bA_Menarche_Context | -0.08 (0.10) | 0.03 (0.11) | -0.15 (0.12) |
| bE_Menarche_Context | -0.08 (0.09) | -0.07 (0.09) | 0.06 (0.09) |
| bA_Perceptions_Context | 0.29 (0.12) | 0.48 (0.14) | 0.30 (0.15) |
| bE_Perceptions_Context | -0.01 (0.07) | -0.05 (0.07) | -0.12 (0.09) |

*Significantly different than zero at $P < 0.05$.

Figure Captions

Figure 1. Behavioral genetic model for age at menarche, perceived pubertal development and age at first intercourse (AFI). A, Additive genetic C, shared environment; E, non-shared environment. Only one twin is illustrated.

Figure 2. Behavioral genetic model for age at menarche, perceived pubertal development and three relationship contexts (dating, relationship sex, and non-relationship sex). A, Additive genetic; E, non-shared environment. Only one twin is illustrated.

Figure 3. Mean age at menarche for adolescents that engage in dating, romantic relationship sex, and non-romantic relationship sex, and for adolescents that do not engage in the three contexts.

Figure 4. Mean perceived development for adolescents that engage in dating, romantic relationship sex, and non-romantic relationship sex, and for adolescents that do not engage in the three contexts.

Figure 5. Effect sizes for age at menarche and perceived physical development on dating, sex in a romantic relationship, and sex in a non-romantic relationship.

Note. Effect sizes represented as Cohen's *d*. "Phenotypic" effect sizes represent mean differences between individuals who did versus did not report each behavior. "Within-family" effect sizes represent mean differences between siblings discordant for each behavior.

If the magnitude of the within-family effect is attenuated compared to the phenotypic effect, this suggests that genetic and/or shared environmental factors in the same family account for the behavioral differences. If the effect is not attenuated, findings support an environmental mechanism for depressive symptoms being influenced by adolescent dating and sexual experiences.

Figure 1

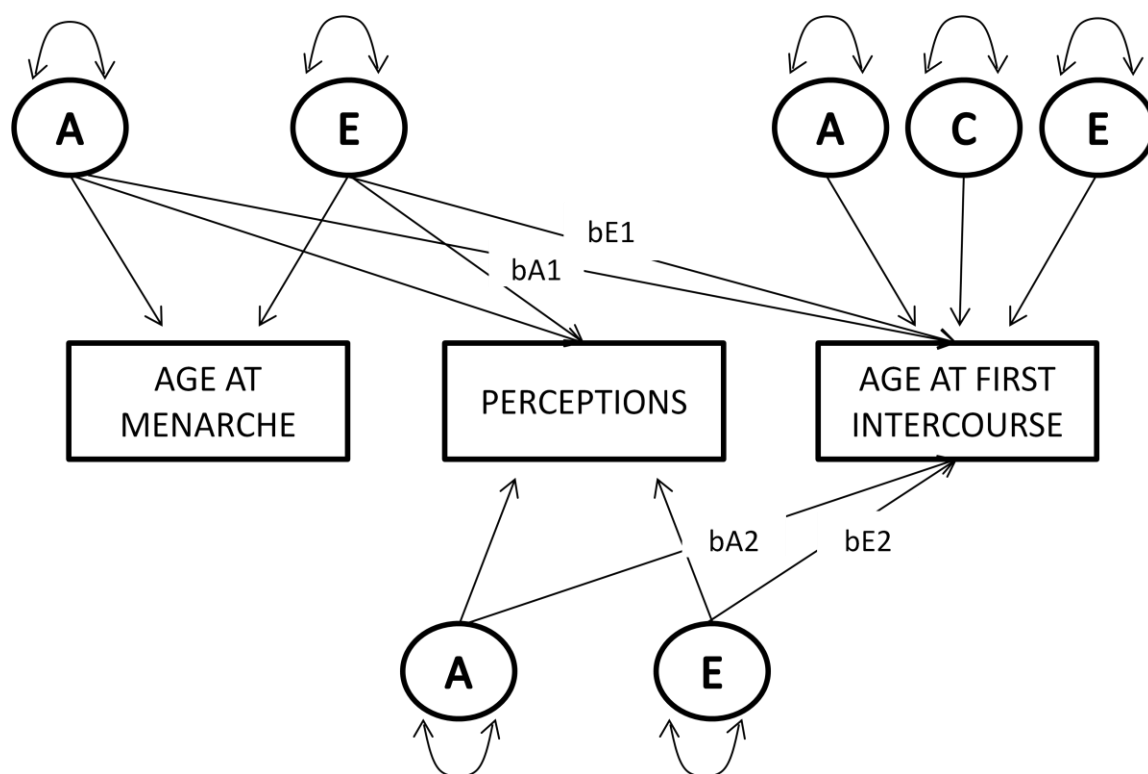


Figure 2

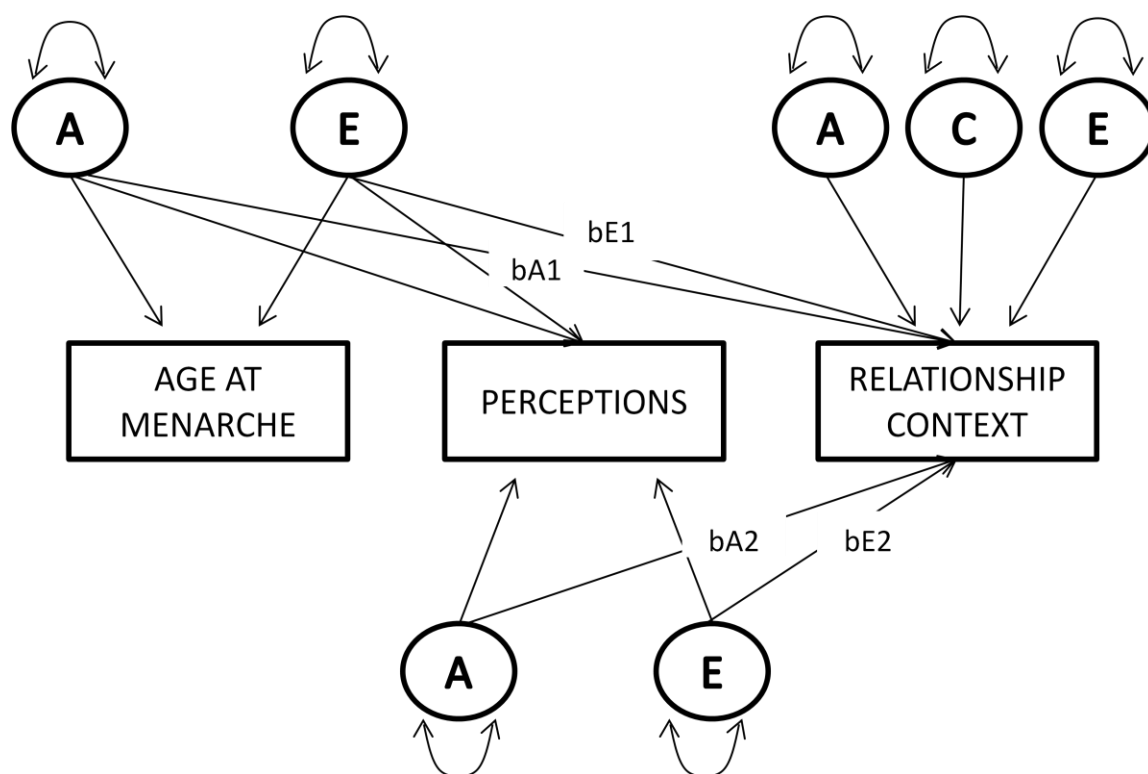


Figure 3

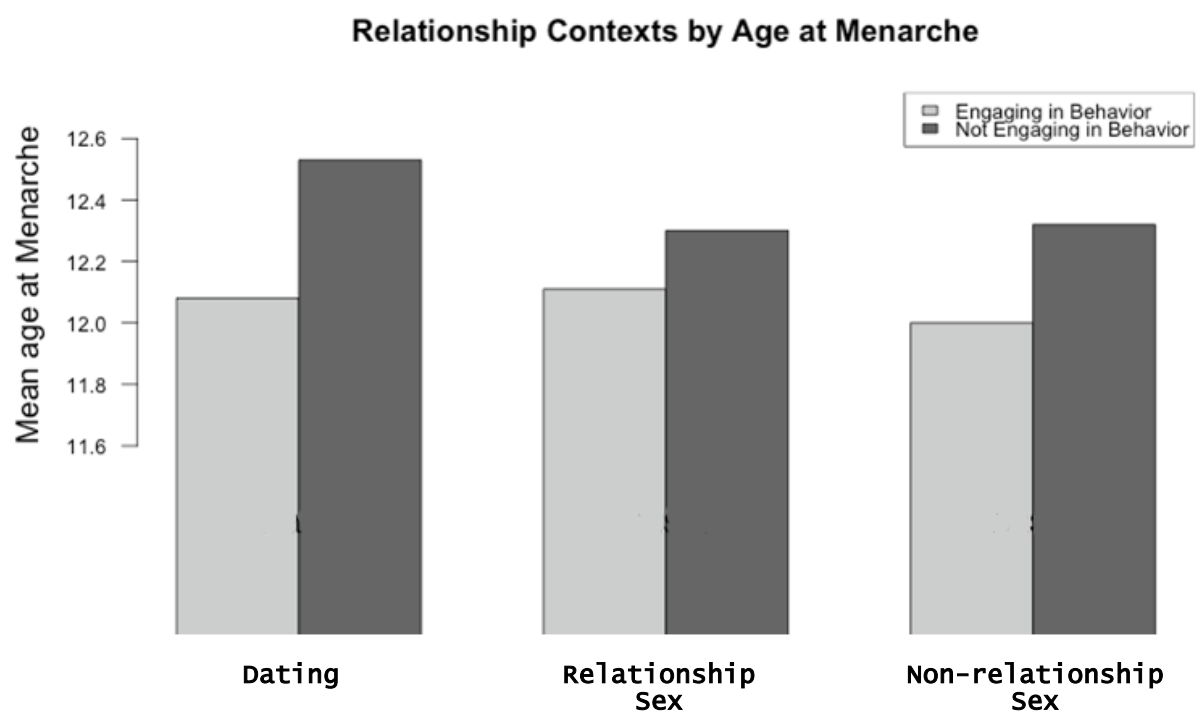


Figure 4

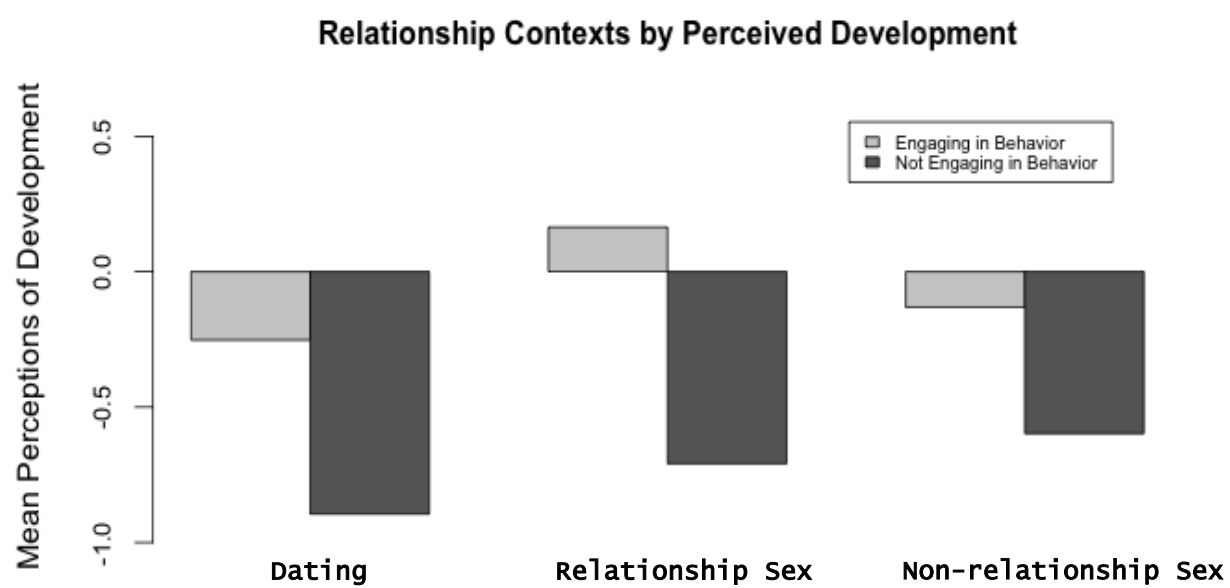


Figure 5

